

What is claimed is:

1           1. An apparatus for calibrating vacuum nozzle positions  
2           in a component placement machine, comprising:

3                 a) a housing adapted for movement relative to a  
4                 printed circuit board and having a frame rotatably  
5                 attached thereto, said frame having a plurality of  
6                 pick/place heads disposed thereupon, each of said  
7                 pick/place heads comprising a vacuum spindle being  
8                 extendable and having a vacuum nozzle at a distal end  
9                 thereof, each of said vacuum nozzles being adapted for  
10                performing at least one of the operations of picking,  
11                holding, orienting, transporting, and placing a component  
12                relative to a printed circuit board;

13               b) a vision system comprising at least one camera,  
14               said camera operatively disposed with respect to and  
15               contiguous with said housing and adapted for capturing an  
16               image of at least one of said vacuum nozzles after  
17               placing a component;

18               whereby said at least one of said vacuum nozzle positions  
19               is calibrated using said vision system and said captured  
20               image before picking the next of said component.

1           2. The apparatus for calibrating vacuum nozzle positions  
2       in a component placement machine of claim 1, wherein said  
3       vacuum spindle is in the extended position when positioned at  
4       said camera.

1           3. The apparatus for calibrating vacuum nozzle positions  
2       in a component placement machine of claim 1, wherein said  
3       image is captured and said vacuum nozzle is calibrated during  
4       a single machine placement cycle.

1           4. The apparatus for calibrating vacuum nozzle positions  
2       in a component placement machine of claim 1, wherein said  
3       calibrated vacuum nozzle position is used for picking a  
4       subsequent component.

1           5. A method for calibrating vacuum nozzle positions in a  
2       component placement machine, the steps comprising:

3               a) providing a component placement machine  
4       comprising a plurality of vacuum spindles, each being  
5       extendable and having a vacuum nozzle at a distal end  
6       thereof, each of said plurality of vacuum nozzles being  
7       adapted for performing at least one of the operations of  
8       picking, holding, orienting, transporting, and placing a  
9       component relative to a printed circuit board;

10           b) providing a vision system having a camera  
11           operatively disposed with respect to said plurality of  
12           vacuum nozzle;

13           c) picking a component from a supply of components  
14           using at least one of said plurality of vacuum nozzles;

15           d) placing said component on said printed circuit  
16           board with at least one of said plurality of vacuum  
17           nozzles;

18           e) capturing an image of at least one of said  
19           plurality of vacuum nozzles after said placing with said  
20           camera; and

21           f) calibrating at least one of said plurality of  
22           vacuum nozzles using said captured image before said  
23           picking of next said component.

1           6. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 5, wherein  
3 said calibrating step (f) comprises:

4           i) extending at least one said plurality of vacuum  
5 spindles to an extended position, before said capturing  
6 an image using said vision system; and

7           ii) determining a position of at least one of said  
8 plurality of vacuum nozzles within said captured image  
9 thereby creating a calibrated vacuum nozzle position for  
10 at least one of said plurality of vacuum nozzles.

1           7. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 5, wherein  
3 said calibrating step (f) further comprises:

4           iii) storing information representative of said  
5 calibrated vacuum nozzle position.

1           8. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 5, wherein  
3 said captured image of step (e) is captured in a plane.

1           9. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 5, wherein  
3 said capturing an image step (e) and calibrating step(f) are  
4 accomplished substantially completely during at least one of  
5 said placing step (e) and said picking step (c).

1           10. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 6, wherein  
3 said picking step (c) further comprises using said calibrated  
4 vacuum nozzle position for picking a subsequent component.

1           11. The method for calibrating vacuum nozzle position in  
2 a component placement machine as recited in claim 5, wherein  
3 said vision system comprises at least one camera adapted to  
4 capture an image of at least one of said plurality of vacuum  
5 nozzles.